國立政治大學資訊管理學系
NCCU DEPARTMENT OF MANAGEMENT INFORMATION SYSTEMS

Introduction to Computer Science

Week 2- Computer Hardware

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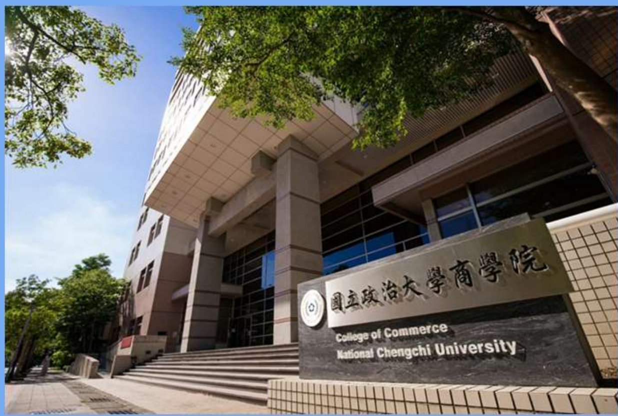
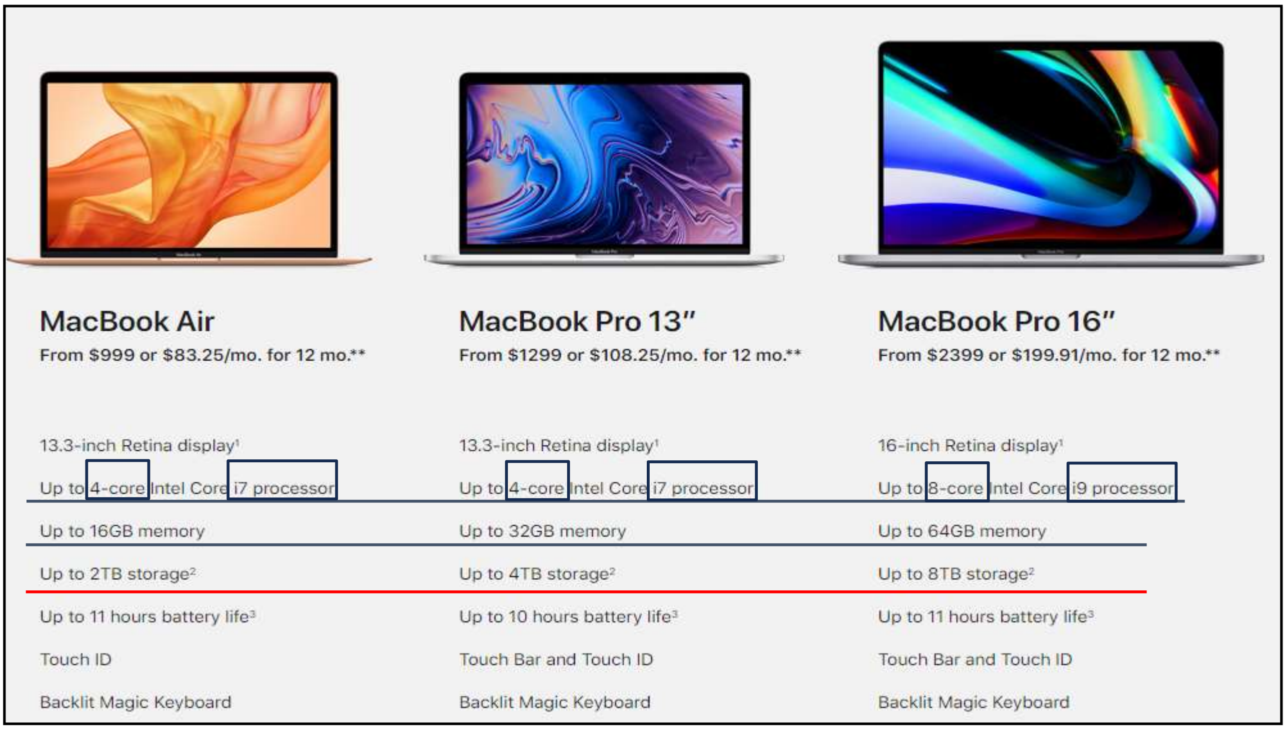


amazon

	This item 2020 Newest ASUS VivoBook 15.6" FHD Thin Light Business Student Laptop, AMD Ryzen 5 3500U(Beat i7-7500U) 8GB RAM 128GB SSD+ 500GB HDD, Radeon Vega 8, Fingerprint, HDMI, USB-C, Win10, w/GM Accessories	2020 Newest ASUS VivoBook 15.6" Full HD Laptop AMD Ryzen 7 3700U 12GB RAM 512GB SSD Radeon RX Vega HDMI WiFi Bluetooth 10 Windows 10 Home Silver	2020 ASUS VivoBook 15 15.6 Inch FHD 1080P Laptop (AMD Ryzen 3 3200U up to 3.5GHz, 8GB DDR4 RAM, 256GB SSD, AMD Radeon Vega 3, Backlit Keyboard, FP Reader, WiFi, Bluetooth, HDMI, Windows 10) (Grey)	2020 Newest Acer Aspire 5 Slim Laptop 15.6 FHD IPS Display, AMD Ryzen 3 3200u-Dual Core (up to 3.5GHz), Vega 3 Graphics, 8GB RAM, 128GB PCIe SSD + 500GB HDD, Windows 10 w/Ghost Manta Accessories
	Add to Cart	Add to Cart	Add to Cart	Add to Cart
Customer Rating	★★★★☆ (32)	★★★★☆ (55)	★★★★☆ (111)	★★★★☆ (122)
Price	$599.00	$729.00	$505.00	$539.00
Sold By	AMAZING WAREHOUSE DEAL(Record SN)	UltraGeek	Trusted eStore	AMAZING WAREHOUSE DEAL(Record SN)
Computer Memory Size	8 GB	12 GB	8 GB	8 GB
CPU Model Manufacturer	AMD	AMD	AMD	AMD
CPU Speed	2.10 GHz	2.3 GHz	2.6 GHz	2.60 GHz
Display Resolution Maximum	1920 x 1080 pixels	1920 x 1080 pixels	1920 x 1080	1920x1080 pixels
Screen Size	15.6 inches	15.6 inches	15.6 inches	15.6 inches
Display Technology	LED	LED	—	LED
Hard Disk Size	128 GB	512 GB	256 GB	128 GB
Item Dimensions	14.10 x 9.10 x 0.80 inches	14.10 x 9.10 x 0.80 inches	14.40 x 9.10 x 0.80 inches	14.31 x 9.74 x 0.71 inches
Item Weight	3.51 lbs	3.80 lbs	3.80 lbs	3.97 lbs
Operating System	Windows 10	Windows 10	Windows 10 Home	Windows 10
Processor Count	4	4	2	2
RAM Type	DDR4 SDRAM	DDR4 SDRAM	DDR4 SDRAM	DDR4 SDRAM
Wireless Communication Standard	Bluetooth	Bluetooth	802.11ac	802.11ac, Bluetooth



Factors to consider in buying a computer

Computer component	Consideration
Platform	Platform: any hardware or software that is used to host a system application or company service - Platform creates a foundation to ensure a program to be executed - Does the hardware or software that I need require a specific platform?
Hardware/ Software specifications	Do I require specific hardware for my tasks? - How much data do I plan to store? Does the software I want to run require certain hardware specification? - Programs that use the instruction set for a particular processor
Form factor	Where will I use the computer? - Mobile vs. one location
Add-on devices	What additional devices will I need? - Camera lenses, touchpad

Computer Generations (1950–present)

Computers built after 1950 follow the von Neumann model

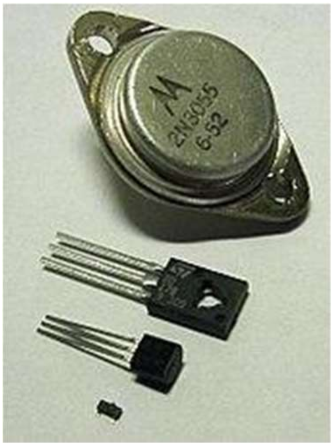
Becoming faster, smaller, and cheaper, but the principle is almost the same

- 1st generation (1950–1959): is characterized by the emergence of commercial computers. Computers used **vacuum tubes** as electronic switches
- 2nd generation (1959–1965): used **transistors** instead of vacuum tubes.
- 3rd generation (1965–1975): used **integrated circuit (IC)** to reduce the cost and size of computers even further
- 4th generation (1975–1985): appearance of microcomputers (desktop calculator). This generation also saw the emergence of **computer networks**
- 5th generation (1985–now): appearance of laptop and mobile devices, improvements in secondary **storage** media (CDROM, DVD, thumb drive), the use of **multimedia**, VR/AR/MR

Transistor (電晶體)

Information is kept and manipulated in the binary formats (off: 0 vs. on: 1)

- Transistor switches are used to manipulate binary numbers
  - Open transistor represents a **0**
  - Closed transistor represents a **1**
- Operations can be completed by connecting multiple transistors



Transistor and Integrated Circuit

Transistor (電晶體)

A semiconductor device used to amplify or switch on/off electronic signals and power (binary system: 1 and 0)

Image credit: https://dcaclab.com/blog/npn-transistor-working-and-application-explained

Integrated Circuit (IC) (積體電路)

A set of electronic circuits on one small flat piece of semiconductor material

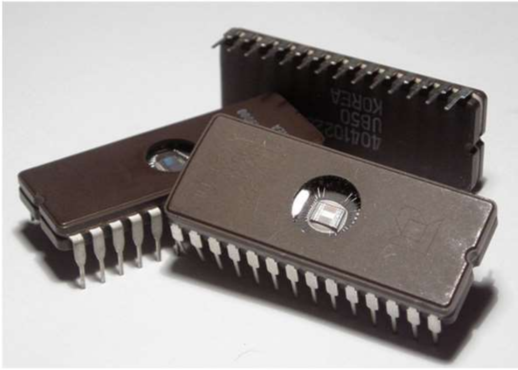
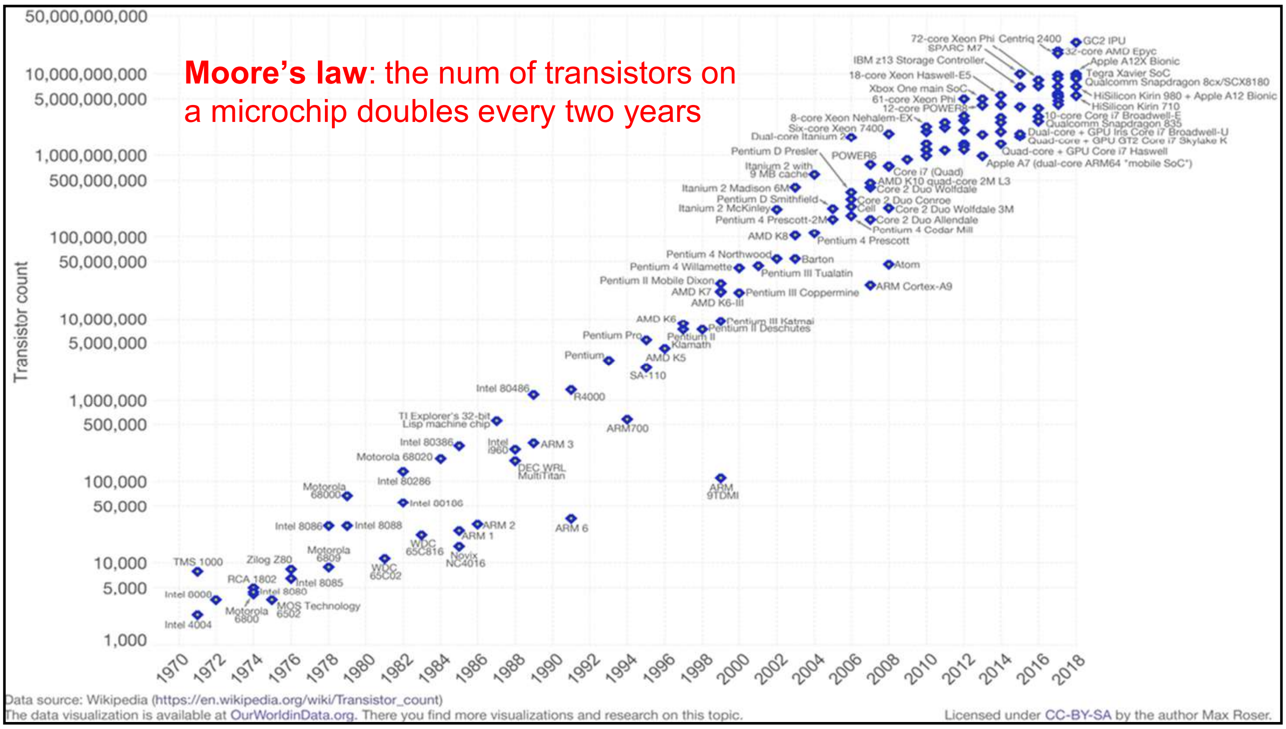
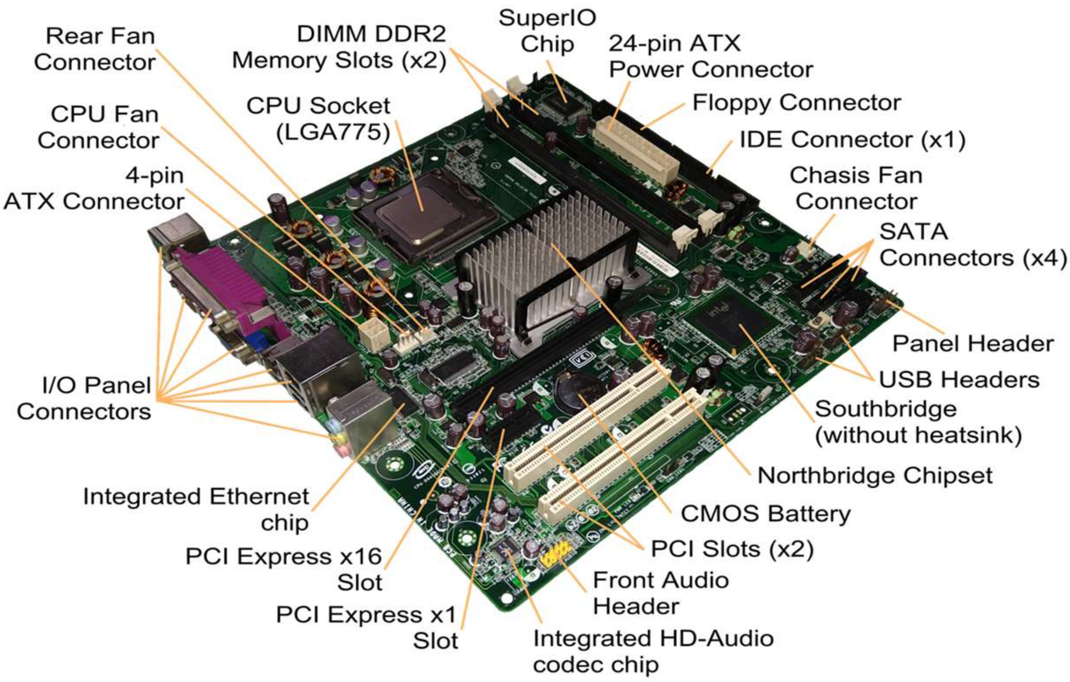


Image credit: https://en.wikipedia.org/wiki/Integrated_circuit





What is a CPU

CPU: Central Processing Unit

Constructed from millions of transistors

CPU executes and processes instructions for your system

CPU determines how fast programs can run

CPU can have multiple processing cores

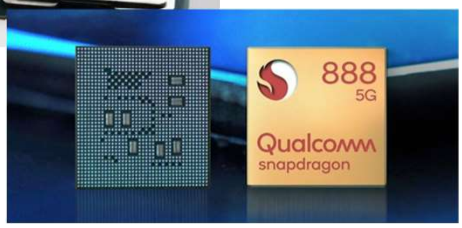


Image credits:
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https://www.4gamers.com.tw/news/detail/38388/intel-readies-new-stepping-of-9th-gen-core-processors

What is a CPU (Central Processing Unit)

CPU: also called central processor or microprocessor

- Interpret and carry out the basic instructions
- Converting input into meaningful output

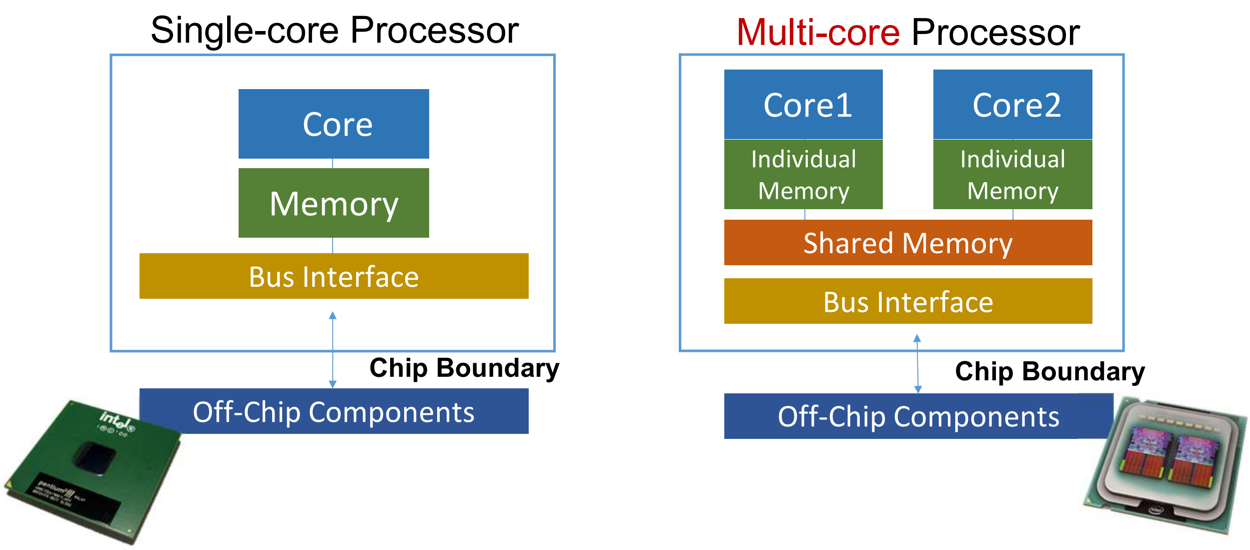
Single vs. Multi-core processors

- Multi-core processor is a single chip with two or more separate processor cores
- Multi-core processor can do parallel computing
    - Single: 5x4x3x2 (one by one)
    - Multi: 5x4=20, 3x2=6, then 20x6=120

Bus: what data travels in and out of the CPU

- Data bus: transfer data and instructions
- Address bus: transfer data address that stored in the memory
- Control bus: transmit control signals

Multi-core processor



Measure CPU Performance

Bus: the channel that allows CPU to communicate with various devices

- Bus ***speed***: num of times a group of bits can be sent each second
- Bus ***width*** (word size): num of bits that can be sent to the CPU simultaneously
  - Wider bus → more data can be transferred (32-bit vs. 64-bit system)

Clock speed rate: the num of clock cycle a CPU can perform per sec

- CPU with a clock rate of 3.6 GHz can perform 3,600,000,000 clock cycles per second

Benchmark test: test run by a laboratory to determine processor speed

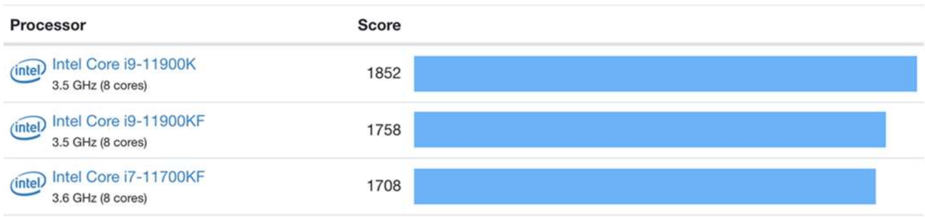
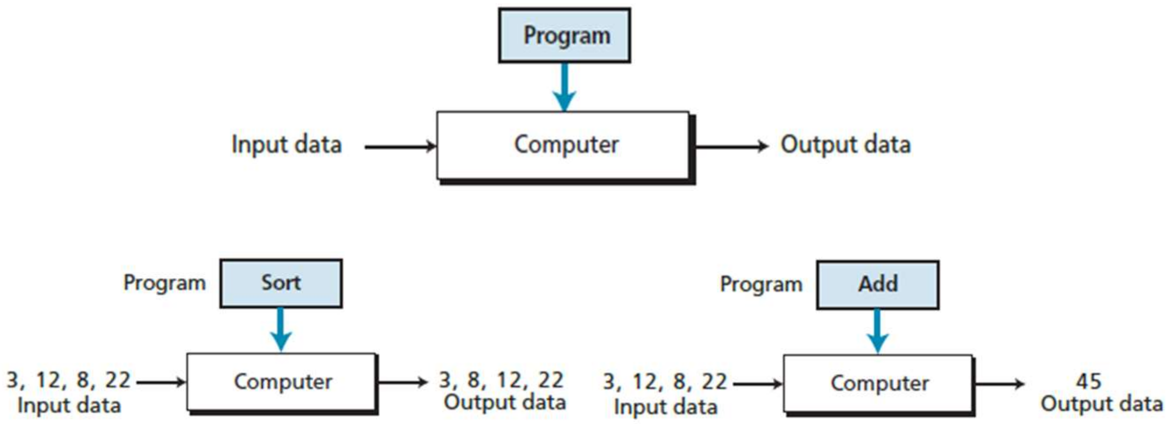


Image credit: https://browser.geekbench.com/processor-benchmarks

Input, Output, and Program

A program is a set of instructions that tells the computer what to do with data



von Neumann Model

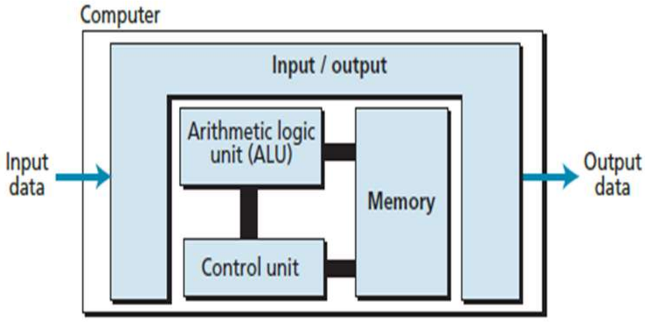
The von Neumann model states that the **program** must be stored in memory

Totally different from the architecture of early computers in which **only the data** was stored in memory

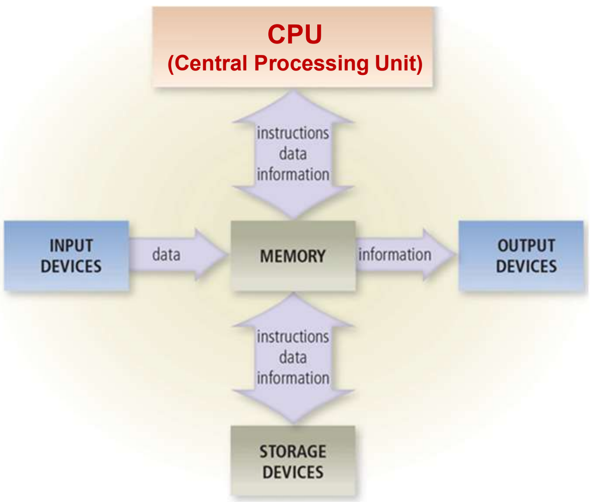
The programs for their task were implemented by manipulating a set of switches or by changing wiring system

Computers built on the von Neumann model divide the computer hardware into four subsystems:

Input/Output, Memory, **CU (control unit)**, and **ALU (arithmetic logic unit)**



Computer Hardware



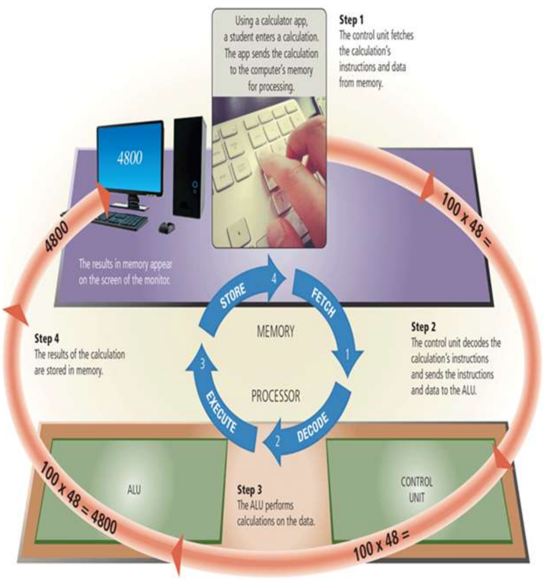


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

CPU Components- ALU & CU

CPU performs operations on data, which has three parts: an **arithmetic logic unit (ALU)**, a **control unit (CU)**, and a set of **registers**

When running an application:

Instructions data are transferred from storage device to memory

CU directs and coordinates the instruction flow in the computer

- CU interprets and executes the instructions in the memory
- CU controls ALU, access to memory and I/O systems

ALU performs logic, shift and arithmetic operations

- ALU performs calculations on data in memory (logic, shift, and arithmetic operation)

Data are stored in **register** for faster access

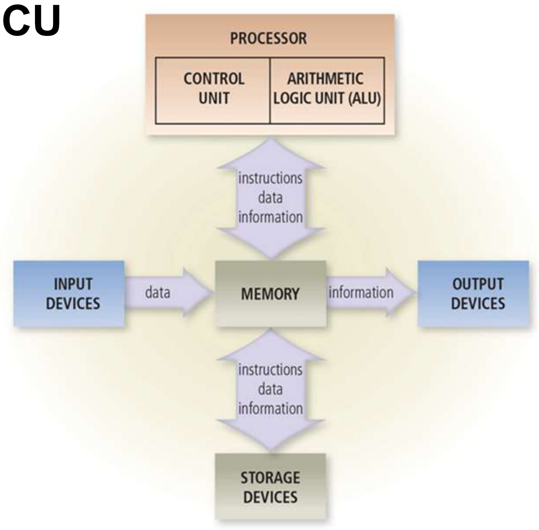


Figure 6-4 Most devices connected to the computer communicate with the processor to carry out a task.

Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

CPU Components- Register

Registers are fast stand-alone storage locations that hold data temporarily

- Multiple registers to facilitate CPU operation

DR (data register): hold the input data, the intermediate results, and the final result of operations

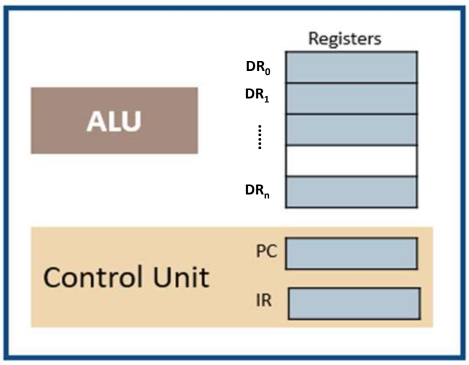
- Numerous DR are inside the CPU to speed up the operations

IR (instruction register): CPU fetches instructions one by one from memory and stores them in IR

PC (program counter): keep track of the instruction currently being executed and to be executed next

- After execution of the instruction, the counter is incremented to point to the address of the memory location of the main memory that holds the next program instruction

CPU



Different registers

DR: data register
IR: instruction register
PC: program counter

Machine Cycle

Machine cycle is the activity performed by CPU to execute a program instruction

For each instruction, the processor repeats a set of four basic operations

Fetch: obtain data or an instruction from memory

- CU orders the system to copy next instruction into IR in CPU
- The address of the instruction to be copied is held in PC register
- After copying, PC is incremented to refer to the next instruction in memory

Decode: translate instructions into signals the computer can execute

- CU decodes the instruction stored in IR and send data and instructions to ALU

Execute: carry out the commands

- CU can tell the system to load a data item from memory, or
- CU can tell ALU to perform calculation (eg, add two inputs)

Storage: store the results in memory

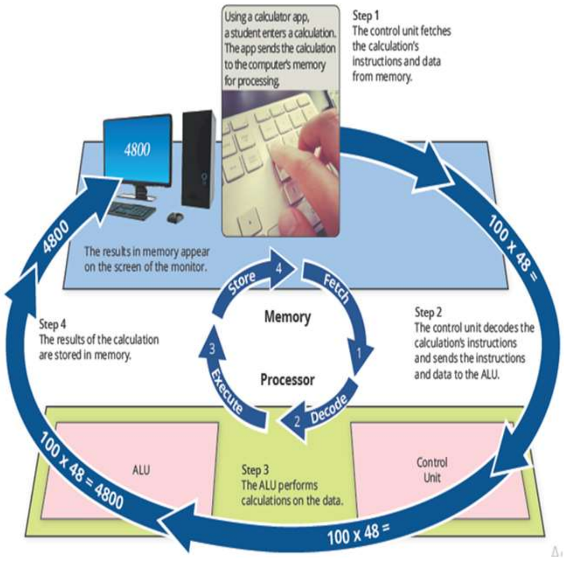


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

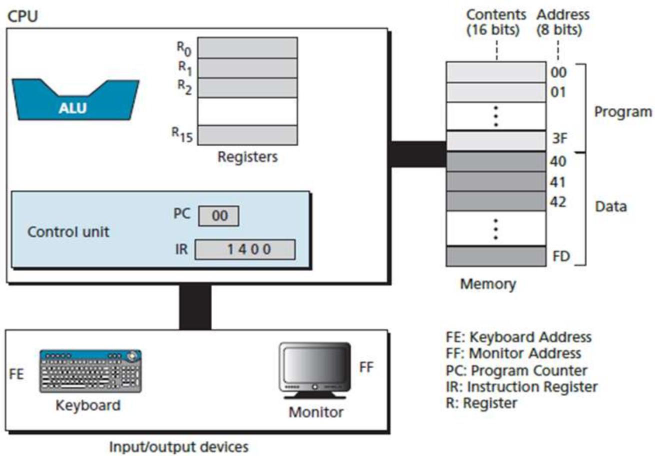
Instruction	*Code*	*Operands*			*Action*
	d_1	d_2	d_3	d_4	
HALT	0				Stops the execution of the program
LOAD	1	R_D	M_S		$R_D \leftarrow M_S$
STORE	2	M_D		R_S	$M_D \leftarrow R_S$
ADDI	3	R_D	R_{S1}	R_{S2}	$R_D \leftarrow R_{S1} + R_{S2}$
ADDF	4	R_D	R_{S1}	R_{S2}	$R_D \leftarrow R_{S1} + R_{S2}$
MOVE	5	R_D	R_S		$R_D \leftarrow R_S$
NOT	6	R_D	R_S		$R_D \leftarrow \overline{R}_S$
AND	7	R_D	R_{S1}	R_{S2}	$R_D \leftarrow R_{S1}$ AND R_{S2}
OR	8	R_D	R_{S1}	R_{S2}	$R_D \leftarrow R_{S1}$ OR R_{S2}
XOR	9	R_D	R_{S1}	R_{S2}	$R_D \leftarrow R_{S1}$ XOR R_{S2}
INC	A	R			$R \leftarrow R + 1$
DEC	B	R			$R \leftarrow R - 1$
ROTATE	C	R	*n*	0 or 1	$Rot_n R$
JUMP	D	R	*n*		IF $R_0 \neq R$ then PC = *n*, otherwise continue

Key: R_S, R_{S1}, R_{S2}: Hexadecimal address of source registers
R_D: Hexadecimal address of destination register
M_S: Hexadecimal address of source memory location
M_D: Hexadecimal address of destination memory location
n: Hexadecimal number
d_1, d_2, d_3, d_4: First, second, third, and fourth hexadecimal digits

Example of Machine Cycle

Example: 161 + 254 = 415

These numbers are shown in the hexadecimal format in memory:
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$



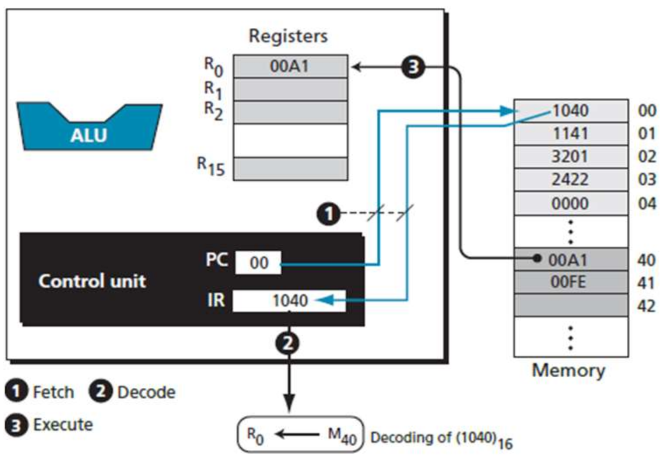
Cycle 1

161 + 254 = 415
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$

The PC points to the first program instruction, memory location $(00)_{16}$

The CU goes through 3 steps:

1. CU ***fetches*** the instruction stored in memory location $(00)_{16}$ and puts it in the IR. Then, PC is incremented (00→01)
2. The CU ***decodes*** the instruction $(1040)_{16}$ as $R_0 \leftarrow M_{40}$
3. The CU ***executes*** the instruction, a copy of the integer stored in memory location (40) is loaded into R_0 ,$(00A1)_{16}$



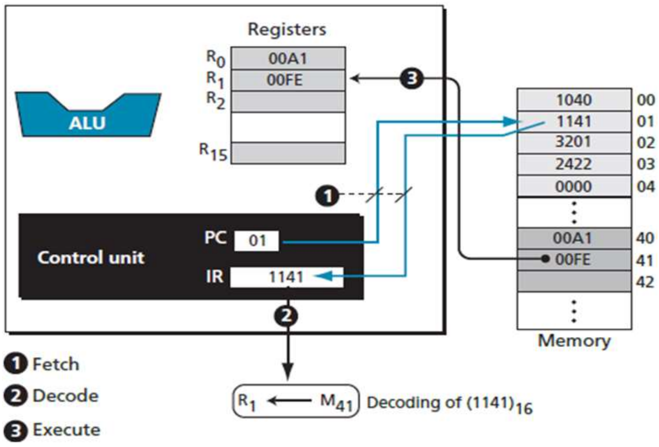
Cycle 2

161 + 254 = 415
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$

The PC points to the first program instruction, memory location $(01)_{16}$

The CU goes through 3 steps:

1. CU ***fetches*** the instruction stored in memory location $(01)_{16}$ and puts it in the IR. Then, PC is incremented (01→02)
2. The CU ***decodes*** the instruction $(1141)_{16}$ as $R_1 \leftarrow M_{41}$
3. The CU ***executes*** the instruction, a copy of the integer stored in memory location $(41)_{16}$ is loaded into R_1 ,$(00FE)_{16}$



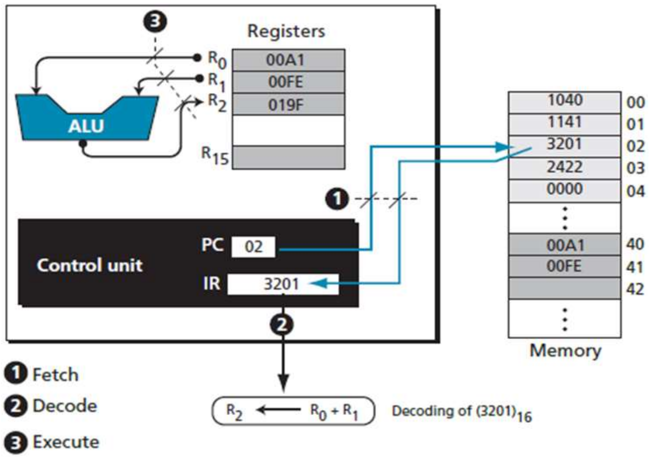
Cycle 3

161 + 254 = 415
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$

The PC points to the first program instruction, memory location $(02)_{16}$

The CU goes through 3 steps:

1. CU ***fetches*** the instruction stored in memory location $(02)_{16}$ and puts it in the IR. Then, PC is incremented (02→03)
2. The CU ***decodes*** the instruction $(3201)_{16}$ as $R_2 \leftarrow R_0 + R_1$
3. The CU ***executes*** the instruction, R_0 is added to R_1 (by ALU) and the result is put in R_2



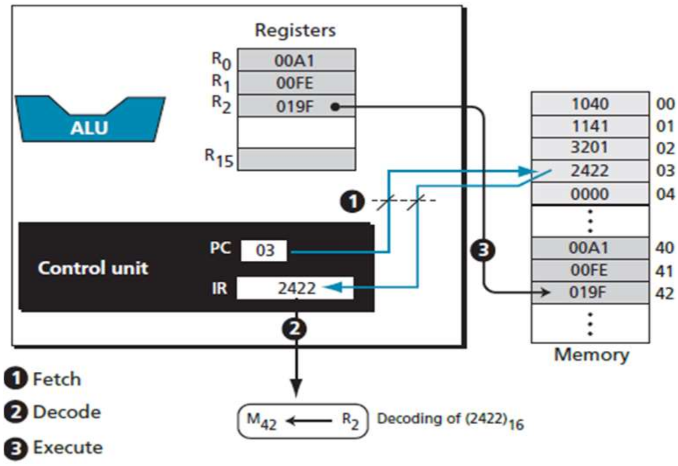
Cycle 4

161 + 254 = 415
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$

The PC points to the first program instruction, memory location $(03)_{16}$

The CU goes through 3 steps:

1. CU ***fetches*** the instruction stored in memory location $(03)_{16}$ and puts it in the IR. Then, PC is incremented (03→04)
2. The CU ***decodes*** the instruction $(2422)_{16}$ as $M_{42} \leftarrow R_2$
3. The CU ***executes*** the instruction, a copy of the integer stored in memory location $(42)_{16}$ is loaded into R_2 ,$(019F)_{16}$



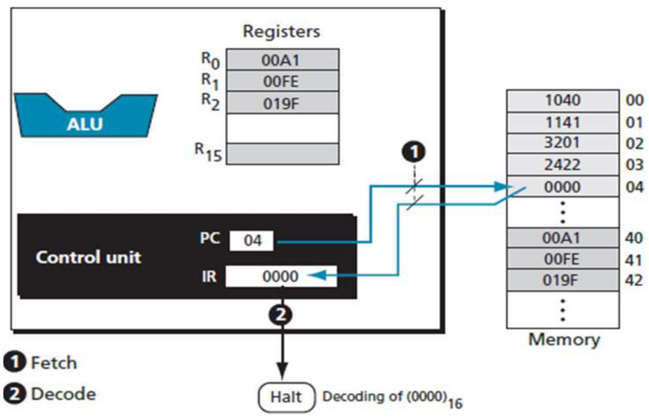
Cycle 5

161 + 254 = 415
161 = $(00A1)_{16}$
254 = $(00FE)_{16}$
415 = $(019F)_{16}$

The PC points to the first program instruction, memory location $(04)_{16}$

The CU goes through 3 steps:

1. CU ***fetches*** the instruction stored in memory location $(04)_{16}$ and puts it in the IR. Then, PC is incremented
2. The CU ***decodes*** the instruction $(0000)_{16}$ as Halt
3. The CU ***executes*** the instruction, which means that the computer stops



Reading and Writing Processes

A **storage device** is the hardware that used to record and/or retrieve items to and from storage media

Reading is the process that transferring items from a storage medium into memory

Writing is the process of transferring items from memory to a storage medium

Storage

A storage medium is the physical material on which a computer stores data, information, programs, and applications

Cloud storage keeps information on servers on the Internet, and the actual media on which the files are kept are transparent to the user

Internal hard drive

Photo by Vincent Botta on Unsplash

USB flash drive

Image by FlitsArt from Pixabay

Memory cards

Image by Photo Mix from Pixabay

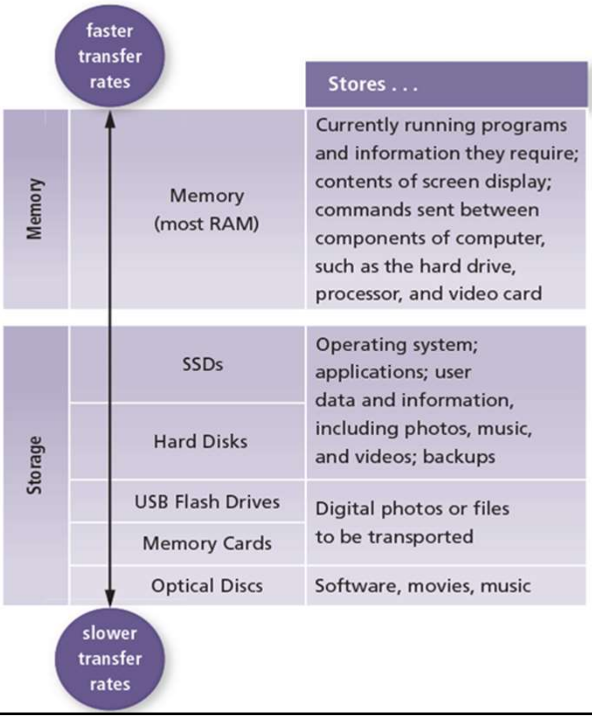
External hard drive

Photo by：Jessica Lewis · from：Pexels

Access Time

Access time measures:

- The amount of time that a storage device takes to locate an item on a storage medium
- The time required to deliver an item from memory to the processor
- Memory is faster but more expensive
- Storage is cheaper but slower



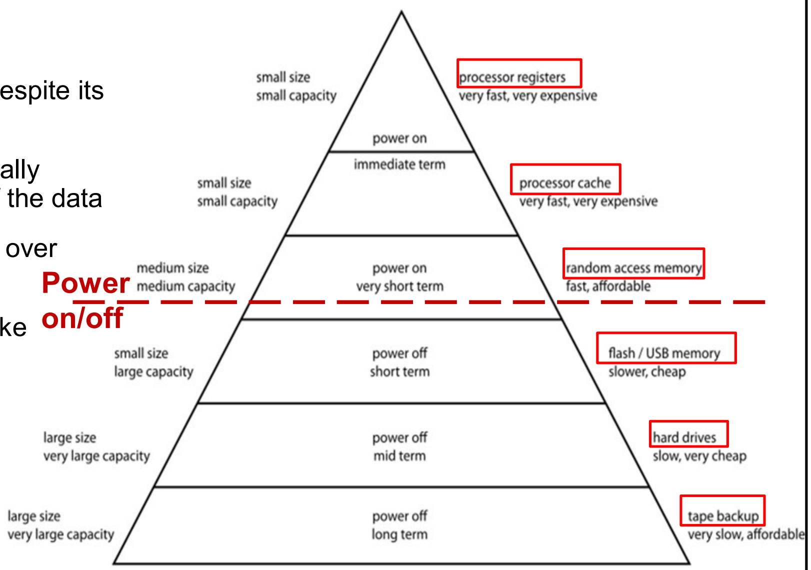
Computer Memory Hierarchy

Why (cache) memory is so efficient despite its small size?

The 80:20 rule: most computers typically spend 80% of time accessing 20% of the data

The same data is accessed over and over again

Cache memory holds this 20% to make access faster



Cache Memory

Speed: Register > Cache > Main memory

Cache is placed between CPU and main memory

Cache stores frequently used instructions and data (a copy of a portion of main memory)

- Data might be needed again soon
- Speed up processing times

When CPU needs to access a word in main memory:

1. CPU checks cache
2. If the word is there, CPU copies the word.
   If not, CPU accesses main memory and copies a block of memory starting with the desired word.
   This block replaces the previous contents of cache memory
3. CPU access the cache and copies the word

L1 & L2 cache built directly on the processor chip

L3 cache is on the motherboard

- L1: fastest but smallest; L3: largest but slowest

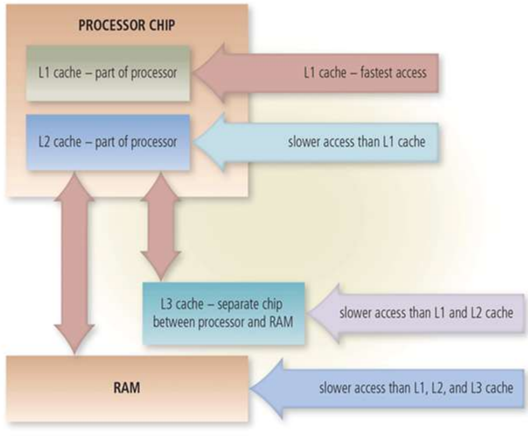


Figure 6-14 Memory cache helps speed processing times when the processor requests data, instructions, or information.

Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Types of Memory – RAM (Random Access Memory)

Memory consists of electronic components that store instructions waiting to be executed by the processor

- Volatile vs. nonvolatile memory

RAM (random access memory)

- Contents of RAM are lost when power is off (volatile)
- Temporarily store data required by the operating system and apps
- When an app is launched, the instructions of the app are transferred from the hard drive to the RAM
- Dynamic RAM (DRAM): memory needs to be constantly charged or the contents will be deleted
- Static RAM (SRAM): memory charge frequency is less than DRAM, faster but more expensive than DRAM

Types of Memory – ROM (Read-Only Memory)

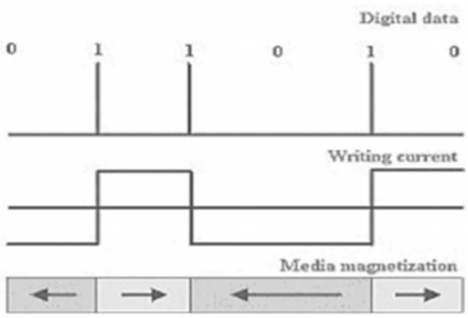
ROM Contents are NOT lost when power is removed (nonvolatile)

- The ROM chip contains the **BIOS** (instructions to start a computer)
  - Power-on self test: whether all computer components are ready
- ROM provides means to communicate b/t operating system and hardware devices
  - Firmware: low-level control for a device's specific hardware
  - Updated firmware version allows you to fine-tune the communication with other devices
    - PROM (programmable ROM)
    - EPROM (erasable PROM)
    - EEPROM (electronically erasable PROM)

Image credit: https://en.wikipedia.org/wiki/EPROM

Hard Drives

Hard disk or hard disk drive (HDD) contains one or more non-fixed, circular platters which use magnetic particles to store data, instructions, and information



https://www.youtube.com/watch?v=wteUW2sL7bc

Hard Drives

Step1.

The circuit board controls the movement of the head actuator and a small motor

Step2.

A small motor spins the platters while the computer is running

Step3.

When software requests disk access, the read/write heads determine the current or new location of the data

Step4.

The head actuator positions the read/write head arms over the correct location on the platters to read or write data

https://www.youtube.com/watch?app=desktop&v=3owqvmMf6No

Characteristics of Hard Disk

Before reading from or writing on a hard disk, the disk must be formatted

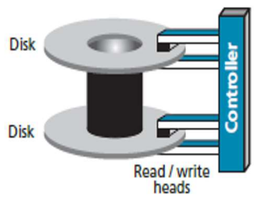
Track is a narrow recording band that forms a full circle on the surface of a disk

- **Cylinder**: tracks that line up on each platter from top to bottom and can be read at the same time

Breaking the tracks into small arcs called sector

- A sector stores up to 512 bytes of data
- Several sectors (n>1) form a **cluster**

Revolutions per minute (RPM) : the number of turns in one minute



a. Disk drive

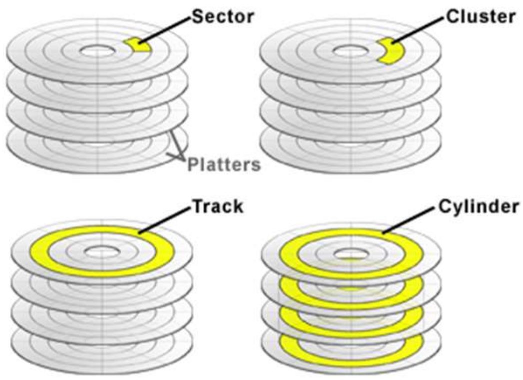


Photo credit: https://goo.gl/images/3vyj6n
Phot credit: https://goo.gl/images/hyMSA1

Solid State Drive (SSD)

SSD (**solid state drive**) is a flash memory storage device that contains its own processor to manage its storage

An SSD has several advantages over traditional (magnetic) hard disks:

- Faster access times
- Faster transfer rates
- Quieter operation
- More durable
- Lighter weight
- Less power consumption
- Less heat generation
- Longer life
- Defragmentation not required

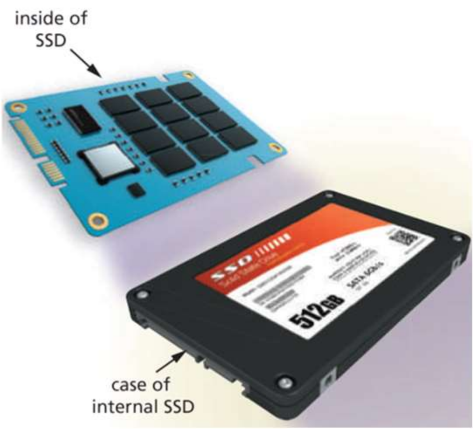


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Virtual Memory

Running more applications at the same time will require more RAM

- Exchange the content b/t RAM and hard drive
- Virtual memory is a part of a storage medium that acts as additional RAM
- The area of the hard drive used for virtual memory is called a swap file
  - **Swap** (exchange) data b/t memory and storage
- Page is the **amount of data** that can be exchanged at a given time
  - Swapping items b/t memory and storage is called paging

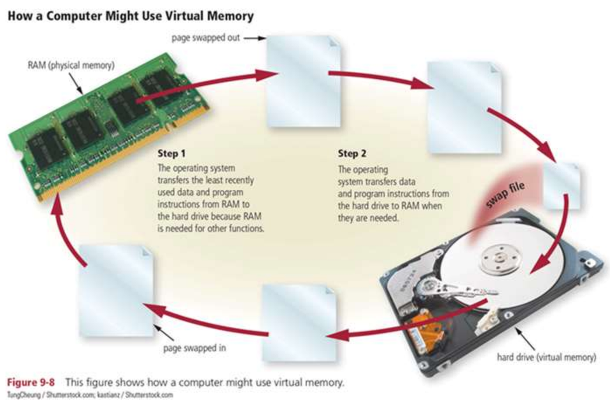


Figure 9-8 This figure shows how a computer might use virtual memory.

https://www.youtube.com/watch?v=qlH4-oHnBb8

Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Binary Number System

Bit (binary digit)

- The smallest unit of data a computer can process

1 Byte = 8 Bits

- Representing a single character in the computer
- Byte is not just 8 values between 0 and 1
- 256 different combinations (ranging from 00000000 to 11111111)

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Storage Capacity

Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	2^{10} or 1,024
Megabyte (MB)	1 million	2^{20} or 1,048,576
Gigabyte (GB)	1 billion **1GB=1000MB**	2^{30} or 1,073,741,824
Terabyte (TB)	1 trillion **1TB=1000GB**	2^{40} or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	2^{50} or 1,125,899,906,842,624
Exabyte (EB)	1 quintillion	2^{60} or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	2^{70} or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	2^{80} or 1,208,925,819,614,629,174,706,176

Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Cloud Storage

Cloud storage : An Internet service that provides storage to computer or mobile device users

iStockphoto.com / Aaltazar

Input Devices

Input methods that are commonly used :

- Keyboard
- Pointing devices
- Touch screens
- Pen input
- Motion input
- Voice input
- Video input
- Scanners and reading devices

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What Is Input?

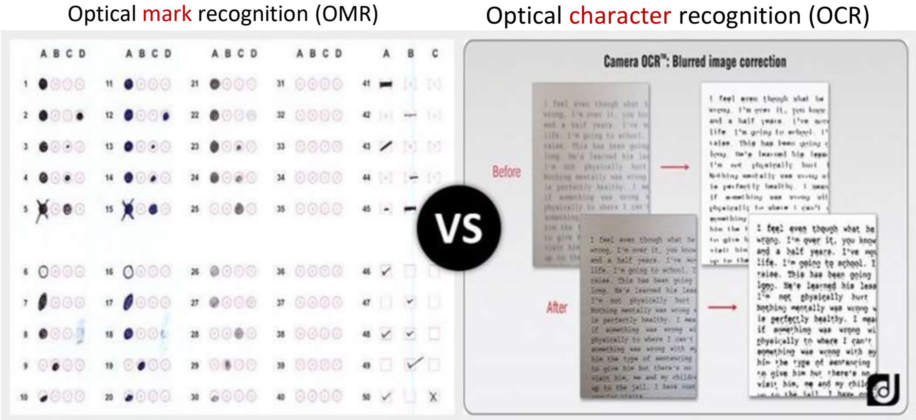
Input : any data and instructions that entered into the memory of a computer

- Keyboard
- Pointing device
    - mouse, touchpad, trackball
- Touchscreen/multitouch screens
- Motion input
- Audio input
- Optical device

Optical Devices

A device that uses a light source to read characters, marks, and codes and then changes them into digital data that a computer can process

Optical mark recognition (OMR) Optical character recognition (OCR)



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Bar Code Readers

Barcode reader (bar code scanner): uses laser beams to read **bar codes**

QR (quick response) code: keeps information in both a vertical and horizontal direction

- Error correction level

recovery capacity 7%

recovery capacity 30%

Video: https://www.youtube.com/watch?v=L4YNWUJD8Do
Photo: https://www.researchgate.net/figure/QR-code-version-7-structure_fig1_304614728

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RFID

RFID (radio frequency identification): uses radio signals to communicate with a tag placed in or attached to an object

RFID reader: reads information on the tag via radio waves

- Tracking times of runners in a marathon
- Tracking location of people and other items
- Checking lift tickets of skiers
- Gauging temperature and pressure of tires on a vehicle
- Checking out library books
- Managing purchases
- Tracking payment as vehicles pass through booths on tollway systems

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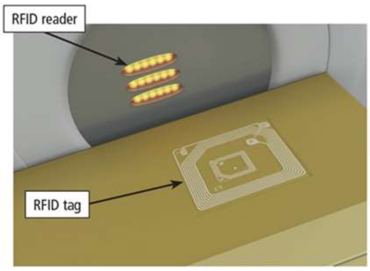
RFID

RFID tag : consists of an antenna and a memory chip that contains the information to be transmitted via radio waves

RFID reader reads radio signals and transmits the information to a computer or computing device



iStockphoto.com / luismmolina

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NFC (near field communication)

An NFC-enabled device contains an NFC chip

An NFC tag contains a chip and an antenna that contains information to be transmitted

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What Is Output?

Data that processed into a useful form

- Display
- Monitor
- Speakers
- Headphones
- Projectors
- Voice synthesizer
- Printers

Image by Michal Jarmoluk from Pixabay

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Display Ports

The monitors today use a digital signal to produce a picture

The monitor should plug in display ports to display the highest quality images:

- VGA port
- DVI port
- HDMI port
- DisplayPort

More details: https://www.youtube.com/watch?v=3LoGJZmyfpA
http://www.brucebnews.com/2014/08/the-confusing-world-of-videovga-dvi-hdmi-displayport/

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How Computers Represent Images

Pixel (picture + element)

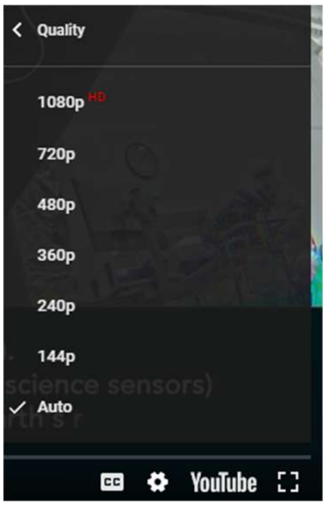
- The smallest picture elements
- Each color is assigned to a binary num
- white:11, black:00

The resolution of the video file is <u>width x height</u>

- The higher the resolution, the clearer the video
- Standard definition (SD): 640 x 320, 720 x 480
- High definition (HD): 1280 x 720 (720p), 1920 x 1080
- 4K: 3840 x 2160 (2160p), 8K: 7840 x 4320 (4320p)

Not all devices can play 4k/8k files

- Play 4k video on 720p display, your computer will convert 4k video to 720p (the best video the screen can provide)



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TO-DO: Final Project (CH)

1. Find your teammates and form the team **wisely**
   - Up to **4** students in a team **(by Sep 19)**
   - Submit your team info
2. Discuss with teammates
3. Submit and prioritize the **3** proposed topics **(by Oct 31)**

IntroToCS_2025_CH		
Name	Student ID	Email
Homer Simpson	112554141	Homer@simpson.com
Marge Simposon	112554142	Marge@simpson.com
Lisa Simposon	112554143	Lisa@simpson.com
Bart Simposon	112554144	Bart@simpson.com
Topic-1:	How AI Can Be Applied in Managing Global Pandemics: Le	
Topic-2:	Timely Fraud Alerts for Protection	
Topic-3:	Educating Users on Mobile Security	

https://ppt.cc/frt93x

TO-DO: Final Project **(EN)**

1. Find your teammates and form the team **wisely**
   - Up to **4** students in a team
   - Submit your team info **(by Sep 19)**
2. Discuss with teammates
3. Submit and prioritize the **3** proposed topics **(by Oct 31)**

IntroToCS_2025_EN		
Name	Student ID	Email
Homer Simpson	112554141	Homer@simpson.com
Marge Simposon	112554142	Marge@simpson.com
Lisa Simposon	112554143	Lisa@simpson.com
Bart Simposon	112554144	Bart@simpson.com
Topic-1:	How AI Can Be Applied in Managing Glob	
Topic-2:	Timely Fraud Alerts for Protection	
Topic-3:	Educating Users on Mobile Security	

https://ppt.cc/f589tx